DOCUMENT RESUME

ED 482 448 HE 036 321

AUTHOR	Ehrenberg, Ronald G.; Rizzo, Michael J.; Jakubson, George H.
TITLE	Who Bears the Growing Cost of Science at Universities?
SPONS AGENCY	Andrew W. Mellon Foundation, New York, NY.
PUB DATE	2003-04-07
NOTE	42p.; Prepared by Cornell Higher Education Research Institute, Cornell University. Support also provided by Atlantic Philanthropies.
PUB TYPE	Reports - Descriptive (141)
EDRS PRICE	EDRS Price MF01/PC02 Plus Postage.
DESCRIPTORS	*Class Size; College Faculty; *Costs; Educational Finance; *Educational Research; *Expenditures; Federal Aid; Higher Education; *Laboratories; Teacher Researchers; *Teacher Salaries; Teacher Student Ratio
IDENTIFIERS	*Starting Salaries

ABSTRACT

This paper sketches the reasons for the tremendous increase in university expenditure on research out of internal funds including changes in federal indirect cost reimbursement policies and the growing cost of start-up funds for new faculty. It presents evidence, based on a survey of department chairs, deans, and vice presidents for research at over 200 public and private universities on the magnitude of start-up packages received by researchers in science and engineering disciplines. It then uses panel data for 21 years and over 200 universities to estimate the impact of growing internal expenditures on research on student/faculty ratios, the substitution of lecturers for tenure track faculty, on average faculty salaries and on tuition levels at public and private universities. Among the most important findings is that universities whose research expenditures per faculty member out of internal funds has been growing the most rapidly in absolute terms, "ceteris paribus," have the greatest increase in student/faculty ratios. So while undergraduate students may benefit from being in close proximity to great researchers, they also bear part of the costs in the form of larger class sizes and fewer full-time faculty members. (Contains 15 references.) (Author/SM)

Reproductions supplied by EDRS are the best that can be made
from the original document.

ED 482 448

Revised Draft
April 7, 2003
Comments Solicited

WHO BEARS THE GROWING COST OF SCIENCE AT UNIVERSITIES?

by

Ronald G. Ehrenberg, Michael J. Rizzo and George H. Jakubson*

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☑ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY
R. Ehrenberg
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

*Ehrenberg is the Irving M. Ives Professor of Industrial and Labor Relations and Economics at Cornell University, Director of the Cornell Higher Education Research Institute (CHERI) and a Research Associate at the National Bureau of Economic Research. Rizzo is a Research Associate at CHERI and a PhD candidate in economics at Cornell. Jakubson is an Associate Professor of Labor Economics at Cornell. They are grateful to the Andrew W. Mellon Foundation and the Atlantic Philanthropies (USA) Inc. for their support of CHERI and to participants at seminars at the National Bureau of Economic Research, Cornell University, George Washington University and the University of Washington for their comments on an earlier draft.

BEST COPY AVAILABLE

Who Bears the Growing Cost of Science at Universities?

Abstract

Scientific research has come to dominate many American university campuses. The growing importance of science is due to exciting breakthroughs in biology, information technology and advanced materials that have promise of tremendously improving human welfare. Along with the growing importance of science has come a growing flow of external funds to universities to support research.

What is not well known, however, is that increasingly the costs of research are being funded at universities are coming out of internal university funds. Over the last three decades of the 20th century the percentage of university research that is funded out of internal funds rose from about 11 to 20 and internal research expenditures per faculty member almost quadrupled in real terms.

Our paper sketches the reasons for the tremendous increase in university expenditure on research out of internal funds including changes in federal indirect cost reimbursement policies and the growing cost of start-up funds for new faculty. We present evidence, based upon a survey of department chairs, deans and vice presidents for research at over 200 public and private universities, on the magnitude of start up packages received by researchers in science and engineering disciplines.

We then use panel data for 21 years and over 200 universities to estimate the impact of growing internal expenditures on research on student/faculty ratios, the substitution of lecturers for tenure track faculty, on average faculty salaries and on tuition levels at public and private universities. Among our most important findings is that universities whose research expenditures per faculty member out of internal funds has been growing the most rapidly in absolute terms, ceteris paribus, have the greatest increase in student/faculty ratios. So while undergraduate students may benefit from being in close proximity to great researchers, they also bear part of the costs in the form of larger class sizes and fewer full-time faculty members.

I. Introduction

Scientific research has come to dominate many American university campuses. The growing importance of science has been accompanied by a growing flow of funds to universities to support research from federal and state government, corporate and foundation sources. What is not well known, however, is that an increasing share of the costs of the research at universities is being funded out of internal university funds. So it is natural for us to ask who bears the growing cost of the internal funds spent on research at universities?

We begin in the next section by sketching the reason for the growing cost of scientific research at universities and the reasons for the growing share of universities' research costs that are funded out of internal university resources. The latter include changes in federal indirect reimbursement cost policies and the growing cost of start-up funds for new faculty. We present evidence on the magnitude of start-up costs that universities face for new researchers in science and engineering fields from a survey that we undertook during the summer of 2002 of department chairs, deans and vice presidents of research at over 200 public and private research universities.

Our paper then turns to an estimation of who bears the costs of internal research expenditures. Using panel data for a 21 year period for 228 research universities, we estimate in the next section the impact of growing internal university expenditures on research on student/faculty ratios and the substitution of lecturers for tenure track faculty, on average faculty salaries and on tuition levels. Perhaps our most important findings are that universities whose research expenditures per faculty member have been growing the most rapidly in absolute terms, other factors held constant, exhibit the greatest increase in

student/faculty ratios and, in the private sector, the largest increases in tuition levels. So while undergraduate students may benefit from being in close proximity to great researchers, they also bear part of the growing costs of research in the form of larger class sizes, fewer full-time professorial rank faculty members and higher tuition levels. However, the magnitudes of these effects are quite small.

Finally, in the brief concluding section, we speculate on future directions that research on the impact of the growing cost of science on academic institutions might take and also about whether the growing efforts by universities to commercialize their faculty members' research may yield sufficient revenues to begin to offset the universities' increasing costs of scientific research.

II. The Growing Importance and Costs of Science

Scientific research has come to dominate many American university campuses and this is reflected in the way universities are ranked. *U.S News & World Report's* annual ranking of national universities as undergraduate institutions places heavy weight on the institutions' expenditures per student and research expenditures are included in this total.[1]

The 1994 Carnegie Foundation classification of PhD granting institutions into Research I, Research II, Doctoral I and Doctoral II institutions was heavily based on the institutions' volumes of external research funding and institutions strove mightily to increase their funding to receive a higher classification in the next Carnegie classification revision.[2] Concerned that universities were placing too much weight on the volume of their faculty members' external research funding and not enough on the quality of their

[1] *U.S. News & World Report* (2001)
[2] Carnegie Foundation for the Advancement of Teaching (1994)

graduate programs, Carnegie collapsed its four PhD institution categories into two in 2000 and based a university's classification solely on the number of PhDs that the institution produced each year.[3] Over 150 institutions are now included in the category doctoral extensive, which includes those institutions that produce the greatest number of doctoral degrees per year. This total is up from the 87 institutions that were classified as Research I in Carnegie's 1994 classification.

As a result of this change, the 2000 classification "watered down" the prestige that universities received from being included among the institutions in Carnegie's "top" university category. Not surprisingly, major research universities increasingly turned to their membership in the prestigious Association of American Universities (AAU), an association of 63 major research universities, to stress their prestige and research universities that were not currently members of the AAU increasingly sought to be admitted.[4] While the specific criteria for being considered for membership in the AAU are not public, an institution's volume of external research funding is clearly important.

Viewed in terms of 1998 dollars, the weighted (by faculty size) average volume of total research and development expenditures per faculty member across 228 American research and doctoral universities increased from about $70,000 per faculty member in 1970-1971 to about $142,340 per faculty member in 1999-2000.[5] This growth in scientific research, which was fueled by the availability of funding from government, corporate and foundation sources, did not derive primarily from the various ranking and

---

[3] Carnegie Foundation for the Advancement of Teaching (2001).

[4] For example, on the page of its World Wide Web Site titled "Claims to Fame", Stony Brook University declares, "As one of the only two universities invited this year to join the Association of American Universities (AAU), Stony Brook becomes one of 63 members that includes such institutions as Harvard, Yale, Johns Hopkins, Princeton and Stanford." (http://www.stonybrook.edu/sb/claims)

[5] The figures that follow are all computed from the NSF WEBCASPAR system (http://caspar.nsf.gov).

classification schemes, but rather from the major advances being made in science and the importance of these advances to our society.

To take but one example, recent advances in decoding the human genome, in advanced materials and in information sciences promise major advances in health care treatment in the years ahead. Any university worth its salt wants to be a leader in these fields so that it can attract top faculty, undergraduate and graduate students, increase its research funding for its programs and potentially achieve financial returns by commercializing its faculty members research (a point we return to below). To illustrate the attention that institutions are paying to promoting the value of their faculty members' research to society, table 1 summarizes the titles of some of the press releases issued by our own university during the first 9 months of 2002 that deal with faculty research in the health and nutrition area.

What is not well recognized, however, is that in spite of generous external support for research, increasingly the costs of research are being borne by the universities themselves. During the 1970-1971 to 1999-2000 period, the weighted average institutional expenditure on research per faculty member at the 228 universities more than tripled. As a result, the weighted average percentage of total research expenditures per faculty member being financed out of institutional funds rose from 11.2 percent to 20.7 percent during the period (figure 1). Increasingly the academic institutions themselves are bearing a greater share of the ever-increasing costs of scientific research.

There are a number of forces that have led to the costs of research borne by universities to soar over the past three decades.[6] Theoretical scientists, who in a previous generation required only desks and pencils and paper, now often require supercomputers.

[6] These forces are discussed in more detail in Ehrenberg (2000, chapter 6) and Ehrenberg (2003).

Experimental scientists increasingly rely on sophisticated laboratory facilities that are increasingly expensive to build and operate. Research administration now includes strict monitoring of financial records and environmental safety, as well as the detailed review and monitoring of experiments involving human subjects.

Historically the federal government and other external funders, through the provision of indirect cost recoveries, have funded much of the research infrastructure that universities operate, as well as their research administration costs. Each institution was allowed to mark-up the direct costs that its faculty members requested from external funders for research support by a multiple called the indirect cost rate and the indirect cost revenues received on successful grant applications went to support the institution's research administration and infrastructure costs. However, after a well-publicized case involving Stanford University in the early 1990s, government auditors began to take a much harder look at universities' requests for indirect cost recoveries and put caps on the expenses that universities could claim for expenses in a number of areas. As a result, the average indirect cost rate at private research and doctoral universities, which was over 60 percent in 1983, fell to about 55% in 1997 and has remained near that level ever since then.[7] On average, for any given level of direct cost research funding which their faculty members received, these private universities received 8.3% less funds from the federal government to support their research infrastructure and administrative costs in 1997 and thereafter than they did in 1983.

---

[7] Indirect cost rates at the public research and doctoral universities were lower at the start of the period and actually rose slightly during the period. The lower initial rates were due to many publics not having to return funds to their state that the state had spent constructing new research facilities. The increase came about because declining state support for operating budgets of public higher education made it more important for the public universities to try to tap all available potential sources of revenue (Ehrenberg (2000, 2003).

What is the likely response of an institution faced with such a reduction in external support for research infrastructure and administration? On the one hand, it might try to reduce its expenditures in these areas to match the decline in the external support for research that it was receiving. But such a strategy would alienate its faculty who would view the institution's commitment to research as declining. In addition, if the reductions were made in areas in which the institution was not spending more than the maximum that the federal auditors would allow it to recover, the auditors would further respond by lowering its indirect cost rate in the following year. So invariably private university administrators made up for the reduction in external funding for research administration and infrastructure by increasing their own institutional commitments.

In recent years the federal government has also placed increasing pressure on all universities to provide "matching" institutional funds for any research proposals that they submit. While universities try to provide matching funds out of funds that they would have spent for research even in the absence of a new external grant, they can not always get away with doing this, especially for large center grant proposals. Put another way, to compete for external funding, increasingly institutions have had to bear an increasing share of the direct costs of their faculty members' research out of their own pockets.

Finally, as scientists' equipment became more expensive and the competition for top-quality scientists intensified, the start-up funding that universities needed to provide to attract young scientists increased. Universities typically cannot recover these expenses in their indirect cost revenues billings, because the new scientists rarely have external funding when they first arrive at the university. During the late 1990s, it was often alleged, although no systematic data existed to support this claim, that universities were

providing young scientists in the range of $250,000 to $500,000 to set up their labs. The start up costs of attracting distinguished senior scientists was often alleged to be much greater and even if these senior faculty members had federally funded research grants, these costs too were often not recoverable in indirect cost recovery pools because the institutions faced caps on their recoveries in a number of categories.

Because no systematic data on start up costs has previously been collected, the Cornell Higher Education Research Institute conducted a "Survey of Start Up Costs and Laboratory Space Allocation Rules" at research and doctoral universities during the summer of 2002. We surveyed the chairs of 3 to 6 narrowly defined science and engineering departments at each institution, the deans of the colleges in which each of these departments were located and the vice president or vice provosts for research in each university. In total 1031 department chairs, 408 deans, and 206 vice presidents or vice provosts received survey questionnaires.

These questionnaires began by describing things that are generally included as start up costs (such as construction or renovation of labs, materials and equipment, support for laboratory staff, graduate assistants or postdoctoral fellows, summer salaries for the faculty member, reduced teaching loads, travel money, unrestricted research funding) and then asked respondents to provide information on the average and/or range of start up costs that they incur for new assistant professors and senior faculty members in their field, on the most expensive sub field in their discipline, on the sources of funding for start up costs, and on the types of laboratory space allocation rules that their units used.

Full results from this survey are available on the Cornell Higher Education Research Institute World Wide Web page (www.ilr.cornell.edu/cheri). Table 2 summarizes some

of the information from the responses of the 572 department chairs (representing a response rate of 55.0 percent) that we received. The department are grouped her into four broad areas – physics/astronomy, biology, chemistry and engineering – and data are reported separately for private Research I, private other, public Research I and public other universities.

Chairs were asked to report either the average start up costs for faculty, or the range of costs for faculty, that they had experienced in the last year or two. Some reported both measures. Table 2 presents the average mean start up costs that the chairs reported for new assistant professors and senior faculty, as well as the average of the high end costs that they reported; in each case the numbers in parentheses are the number of reporting departments in the category.[8]

Table 2 suggests that, with few exceptions, at the new assistant professor level Research I universities provide larger start up packages than other universities and private universities provide larger start up packages than public universities. Average start up costs for assistant professors at private Research I universities in the four fields varied between $390,237 and $489,000.[9] Estimate of the average high-end (most expensive) assistant professor start up cost package at the private Research I universities varied across fields between $416,875 and $580,000.

Start up cost packages for senior faculty members are considerably larger. For example, for the private Research I universities, the average start up costs varied across fields from a low of about $700,000 in physics to a high of about $1,442,000 in engineering. While in general the same pattern of results holds that holds for new

[8] When only a range was reported, we used the midpoint of the range for the average.
[9] Due to the large variability of the size of start up cost packages across institutions in a given field, the differences that we observe between fields (here and below) are not statistically significant.

assistant professors, namely that packages at Research I universities are larger than packages at non-Research I universities and packages at privates are larger than packages at publics, sometimes at the senior level start up costs are larger at Research I publics than at Research I privates. This may reflect efforts by some publics to move to a higher level by bringing in a few key senior faculty members. In any event, start up costs are clearly a major expense faced by American universities.

III. Who Pays for the Growing Importance and Cost of Science?

How have universities responded to the growing importance and costs of science? One might expect that the growing importance of science has provided an incentive for universities to allocate a greater share of their faculty positions or faculty salary dollars, to scientists. However, using data from a set of arts and sciences colleges at leading private research universities, prior work by one of us concluded that over a 20-year period neither the share of faculty positions nor the share of the faculty salary budget devoted to scientists had increased at these colleges.[10] Controlling for the growth of enrollments in the various disciplines or for whether overall faculty size was increasing or decreasing at each college, did not alter these conclusions.

Of course it may well be that the increasing cost of science is felt throughout a university's budget. Colleges of Arts and Sciences may receive a declining share of their university's total faculty positions, even if enrollment changes do not warrant this loss, as more positions are allocated to science intensive engineering and medical colleges. This particular hypothesis is difficult to test because some faculty in the latter two types of

[10] Ehrenberg and Epifantseva (2001)

colleges, especially in medical colleges, are funded on soft money that they raise themselves.

More generally, to the extent that the other sources of income that a university receives, such as state appropriations, annual giving, and endowment income are directed toward supporting an increasingly large scientific infrastructure, this may put upward pressure on undergraduate tuition or cause the university to cut back its expenditures on other areas. Inasmuch as the faculty salary bill represents a large chunk of institutional costs, it is possible that the increasing costs of science are distributed throughout the university in the form of slower rates of increase in faculty salaries and/or in the form of an increase in the student/faculty ratio above the level that would otherwise prevail, all other factors held constant. It is to tests of these hypotheses that we now turn.[11]

A. Does the Increasing Cost of Science Cause a Cutback in Full-time Faculty?

Table 3 uses data from a panel of 228 research and doctoral universities during the 1976-77 to 1997-98 period to explain why an institution's ratio of full-time equivalent undergraduate and graduate students to its full-time professorial ranked faculty varies over time.[12] The explanatory variables, all measured in 1998 dollars, are the institution's research expenditures per professorial ranked faculty out of its own internal funds, the share of its enrollments that are in PhD and nonprofessional masters programs, the level of contributions that it received during the year from all sources per student, its endowment per student, and its state appropriation per student. Undergraduate tuition and

---

[11] By way of background, appendix Figures 1 through 4 plot the mean values of tuition, the student/faculty ratio, average faculty salaries and institutional research expenditures per faculty member during our sample the 1976-77 to 1997-98 period, by Carnegie Category and form of control.

[12] Professorial ranked faculty members include assistant, associate and full professors.

fees levels are omitted as an explanatory variable because they are treated as an endogenous outcome in our work.

All equations also include institutional fixed effects and, as a result, our estimates indicate the impacts of changes over time in the explanatory variables on student/faculty ratios. Separate estimates are provided for private and for public universities and, for each sample, we estimate models without and with year fixed effects. The inclusion of year fixed effects allows for the possibilities that there are omitted macro level variables that influence student/faculty ratios and our other outcomes and we view these estimates as our preferred estimates.[13]

Our key finding is found in the first row of the table. Other factors held constant, universities whose research expenditures are increasing the fastest in absolute terms are also the ones whose student/faculty ratios are increasing the fastest. The magnitude of the relationship is greater in the specification that includes year fixed effects for private universities than it is for publics and we cannot reject the hypothesis for the former that each $10,000 increase in internal research expenditures per faculty member is associated with an increase in the student/faculty ratio of close to 0.5 . During the period the weighted average real institutional research expenditure per faculty member at the private universities in the sample increased from about $7.7 to $17.5 thousand dollars. So on average, the increase in internal research expenditures per faculty member at the privates has caused an increase in student/faculty ratios at them of close to 0.5 during the period,

[13] For example, increases in the unemployment rate may increase students' financial need, which in turn will put pressure on institution's financial aid budgets and influences the salaries that it can afford to pay its faculty and its student/faculty ratio.

as compared to what the student/faculty ratios would have been if the increase in internal research expenditures had not taken place.[14]

The magnitude of the relationship is somewhat lower for the public university sample, .130 in the specification that includes year fixed effects. However, the growth in absolute terms of real research expenditures per faculty member out of internal university funds has been larger for the public universities; the weighted average for public universities in the sample rose from about $7.6 to $31.3 during the period. Hence the impact of the increase in public universities expenditures on research out of their own funds on student/faculty ratios has probably been somewhat smaller, increasing, other factors held constant, by about 0.3 during the period.

Our estimates of the impact of changing internal expenditures on research on the student/faculty ratio prove to be robust to a number of specification changes. Including full-time equivalent student enrollments on the right hand side of the equation did not alter the finding. When we used five-year averages for each institution to capture longer-run changes we found larger student/faculty ratio effects, although they tended to be less statistically significant because of the reduction in our sample sizes.

When we repeated the analyses, using total full-time faculty (including lecturers and instructors) in the denominator of the student/faculty ratio rather than professorial ranked faculty, similar positive coefficients on the research expenditure per faculty member variable were obtained. However, the magnitudes of these coefficients were somewhat smaller than the coefficients in the first row of table 3 in most of the specifications. Hence while the data suggest that an increase in research expenditures per ranked faculty

[14] Appendix figure 1 indicates that during the sample period, student faculty ratios actually only rose slightly at private Research I universities and fell at other private universities in our sample.

member probably does lead to some substitution of full-time lecturers and instructors for professorial ranked faculty, the ratio of students to all faculty (including the lecturers and instructors) also increases when institutional expenditures on research per ranked faculty member increases.

Briefly mentioning other findings from table 3, in the main year-to-year changes in total giving per student do not appear to significantly alter an institution's student/faculty ratio. Increases in endowment per student are associated with increases in student/faculty ratios for the private research universities but decreases in student/faculty ratios for the public research universities. Increases in the levels of state appropriations per student are similarly associated with decreases in student/faculty ratios for the public universities.

What is striking is the impact of changing the share of the total student body enrolled in PhD and nonprofessional masters programs. In the private institutions, growing the share of these programs is associated, other factors held constant, with a higher student/faculty ratio, while in the public institutions it is associated with a lower student/faculty ratio. The private result is intuitive; growing PhD programs may require more money for graduate assistantships and the substitution of graduate assistants for full-time faculty. The public finding is less intuitive. A number of states provide more resources per student to public universities for graduate students than undergraduate students and this might lead to a lower student/faculty ratio. However, we have already controlled for state appropriations per student in our model, so this cannot be the explanation for this finding.

B. Does the Increasing Cost of Science Cause a Slow Down in Faculty Salary Increases?

Table 4 provides estimates of equations similarly specified to those found in table 3, save that the dependent variable is now the real weighted (across ranks) average faculty salary at the institution. Focusing on the specifications with year fixed effects, for both types of institutions we find evidence that increasing an institution's internal research expenditures per faculty member leads, other factors equal, to higher (not lower) faculty salaries. This may reflect reverse causality – high paid faculty members with strong research records being recruited and requiring (see the previous section) considerable funding for start up costs.

Increases in giving levels per student and endowment per student are associated for privates with greater increases in faculty salaries. Similarly increases in state appropriations per student are associated in public universities with increases in average faculty salaries. An increase in the share of students that are in PhD or nonprofessional masters programs is associated with higher average salaries in both sectors; this may again reflect the university's need to hire better and more highly paid faculty with larger PhD programs.

C. Does the Increasing Cost of Science Cause Increases in Tuition Levels?

Table 5 provides similarly specified equations, save that now the dependent variable is the institution's real tuition level. The results suggest that private universities that increase their expenditures per faculty member out of their own funds on research, other factors held constant also increase their tuition levels at higher rates. However, the magnitude of the relationship differs substantially in the models with and without year

fixed effects. Treating the two coefficients as upper and lower bounds to the true relationship, given that the weighted average internal expenditures on research at private universities in the sample increased by about $10,000 per faculty member over the period, our estimates suggest that undergraduate tuition levels at these institution were between $165 and $945 higher in real terms in 1998 than they otherwise would have been. While we view the lower bound estimate, the one coming from the model that included year fixed effects, as the preferred one, even the larger estimate is small compared to the average tuition and fee level of over $20,000 that prevailed at selective private research universities in that year.

All the models suggest that as the share of PhD and nonprofessional masters' students' increases at these universities that tuition levels also increase, other factors held constant. During the period, these shares rose, on average, from .240 to .306 at the private research universities and from .145 to .178 at the public research universities. Our estimates thus imply that tuition levels at the private research universities were between $336 (model with year fixed effects) and $2049 (model without year fixed effects), and those at the public research universities between $50 (model with year fixed effects) and $299 (model without year fixed effects) higher at the end of the period, in real terms, than would otherwise have been the case.

Hence, other factors held constant, undergraduate students bear some of the cost of increased size PhD programs in the form of higher tuitions.[15] We place greater weight on the lower bound estimates that are based on models that include year fixed effects,

[15] We should stress, in keeping with the views of Gordon Winston (1999), that we are not saying that undergraduate students are subsidizing Ph.D. students. Rather, all students attending the research universities receive subsidies and growing the relative size of Ph.D. programs simply reduces the size of the monetary subsidy that undergraduate students receive.

because omitted macro level variables, such as family income, influence students' financial need and ability to afford to attend college, and thus likely influence tuition. Hence the costs that the undergraduate students bear are probably not very large. In addition, if growing PhD programs attract better faculty to universities, undergraduate students may also benefit from increases in the relative size of these programs.

Increased annual giving per student and increased endowment per student are both statistically significantly associated with higher levels of tuition per student. Higher levels of endowment and annual giving provide increased subsidies for students, increase the attractiveness of the university to students and hence should increase the tuition levels that students are willing to pay to attend the university.[16] Results for the increase in state appropriations per student are more mixed, without the inclusion of year fixed effects state appropriations per student are positively associated with tuition increases in the public sector, but in the preferred specification, when the year effects are included, the relationship becomes negative. [17]

D. Some Sensitivity Analyses

Tables 6, 7 and 8 provide two different types of sensitivity analysis for the impact of changes in institutional expenditures on research per faculty member on student/faculty ratios, average faculty salaries and tuition levels, respectively. First, we test whether the relationship differs across Research I and other universities in the sample. Second, we see

---

[16] Again see Gordon Winston's (1999). Empirical evidence that in-state and out-of-state tuition levels are positively associated with levels of endowment per student at public university is also found in Rizzo and Ehrenberg (forthcoming).

[17] Of the 23 private research universities receiving state appropriations, 14 were in New York State and under the Bundy Aid program these institutions received grants for each New York State resident who received a degree from them. During the sample period, the real value of the Bundy aid per graduate declined, as did the share of their graduates coming from New York State. Thus, the negative coefficient of the state aid variable in the private tuition equation may simply reflect the increased need for tuition revenue that they faced as this source of revenue was falling. Once we control for year specific effects, this negative coefficient becomes statistically insignificant for private institutions.

how the estimated relationships differ when we estimate a more complex model in which changes in annual giving, research per faculty member out of external funds and state appropriations are treated as endogenous.

Our changes in external research per faculty member equation allows these changes to depend upon changes that the institution makes in institutional research expenditures per faculty member (through the route of start-up costs, matching funds and more general research infrastructure support), changes in the national research budgets that different government agencies are receiving, and the shares of external research funding in the prior year that an institution received from the various agencies. So, for example, holding the change in institutional research funding constant, institutions that derive a greater share of their external research budget from NIH should see greater increases in their external research funding than institutions that derive a greater share of their research funding from NSF, when the NIH research budget rises relative to the NSF research budget.

Previous research has shown that at private research universities higher levels of total research spending per faculty member are associated with higher levels of annual giving.[18] So we also estimate a change in annual giving equation that allows this change to depend upon the change in total research expenditures per faculty member at the institution. Finally, some states explicitly or implicitly reward institutions for increasing their volumes of external research funding and so we estimate changes in state appropriations per student equations that are specified to depend upon institutions' changes in external research volume per faculty member.

---

[18] Ehrenberg and Smith (forthcoming)

In the context of this more complex model, a change in internal research expenditures per faculty member will directly affect each of our three outcomes and indirectly affect them through its effect on the change in external research expenditures, which in turn may affect state appropriations per student and (along with the change in institutional research expenditures per student) annual giving per student.

Table 6 presents estimates of the coefficient of the internal research expenditures per faculty member variable in the student/faculty equation for various models. The top row of the first two columns (under "baseline"), reports the coefficient estimates from table 3. The next two rows report similar coefficients when the data are stratified into to Research I and other institutions. Statistically significant effects on the student/faculty ratio appear primarily for the Research I universities.

The next four columns display the estimated coefficients of the internal research expenditure per faculty member variable when first giving and external research expenditures and then these two variables plus state appropriations are treated as endogenous in the model. The coefficients of the internal research expenditure variables are remarkably robust to the two sets of endogenity assumptions.

Table 7 presents the similar coefficient estimates from the faculty salary equation. Changes in internal research expenditures per faculty member are positively associated with changes in faculty salaries primarily at public institutions, with the magnitude of the effects being largest at the Non Research I institutions, the ones that probably need to offer higher salaries to attract more research oriented faculty. Again, treating changes in annual giving, external research expenditures and state appropriations as endogenous, does not substantially alter any of these coefficients.

Finally, table 8 presents the coefficient of the internal research expenditure per faculty member variable in the tuition equation. The major finding here is that it is the non Research I private institutions at which the largest impacts on tuition is observed. Again treating the changes in annual giving, external research expenditures and state appropriations as endogenous does not substantially alter any of the coefficients.

To compute the total impact of changes in institutional research expenditures on each outcome requires us to know the impact of changes in internal research expenditures on external research expenditures, changes in external research expenditures on state appropriations and changes in total research expenditures on annual giving per students. Appendix table 1 summarizes the key coefficients that we obtained. For example, at the private research universities giving per student increases by about $395 in response to each $10,000 per faculty member increase in total research volume and external research expenditures per faculty member increase by about $17,300 for each $10,000 increase in institutional research expenditures per faculty member, all other variables held constant. We find, however, no evidence that increases in external research volume per faculty member is statistically significantly related to state appropriations per student.

One can then use these coefficients, as well as the coefficients from the outcome models that were previously reported to compute the total effect of changes in internal research expenditures per faculty members on each of the outcomes. These are the direct effects that operate through the coefficient of this variable in each equation, as well as the indirect effects that operate through the effects of changes in institutional expenditures on research per faculty member on the other variables that we treated as endogenous.

Table 9 summarizes our findings. The row titled "basic model" summarizes the effects that we obtained from the baseline models that were presented in tables 6, 7 and 8. The following rows summarize the direct effects, the indirect effects and the total effects from the model that allows for the endogenity of external research per faculty member, annual giving and state appropriations. The magnitudes of the effects in the total effects row are very similar to the magnitudes of the effects in the basic model row. On balance, treating these other variables as endogenous does not alter any of our main findings.

IV. Concluding Remarks

Our research suggests that undergraduate students bear at least part of the increased costs that American universities are undertaking for their faculty members' scientific research in the forms of higher student-faculty ratios, some substitution of lecturers for professorial rank faculty and, in private universities, higher tuition levels. However, the magnitudes of these effects are surprisingly (to us) small. Whether these costs are more than offset by the benefits the students receive from being educated in proximity to scientific researchers who are at the cutting edge of their disciplines is an open question that deserves serious study.

Our research also suggests that as the share of PhD students and nonprofessional masters' students increases at both the public and private research universities that undergraduate tuition also increases at these universities, other factors held constant. While Gordon Winston's (1999) work indicates that no undergraduate student at a major university bears the full cost of his or her education, our results suggest the undergraduates bear a part of the cost of graduate education, in the sense that the average subsidy (in Winston's terms) that they receive from attending the university is lower

because of the presence of more graduate students. Again whether these costs are more than offset by the benefits that the students receive from being educated close to (and sometimes by) graduate students is an open question deserving of serious study.

Our study has only begun to touch on the impact on the university that institutions' growing cost of science has had. The relatively small impacts that we observed on student/faculty ratios may mask decreases in scientists teaching loads that have taken place, which in turn may have led to larger class sizes. The growth of science may have crowded out other things. For example, increased institutional support for teaching or research assistants for scientists and for stipends for graduate students in the sciences may have led to decreased availability of funds to support teaching assistants or graduate students on fellowships for humanists and social scientists, or slower rates of growth of graduate student stipends in these fields.[19] Or to take another example, increased institutional support for scientific research facilities and start-up costs for scientists may have reduced the funding that otherwise would have been available for travel and other "perks" in the humanities and social sciences.

It is possible, of course, that the increasing costs of research that are borne by universities may be eventually at least partially offset by revenues that the universities receive from increased commercialization of their faculty members' research. The Association of University Technology Managers (AUTM) reported in their fiscal year 2000 survey of their members that American colleges and universities received more than $1 billion dollars in licensing income and other forms of royalties relating to patents that year. While this figure seems large, it was concentrated in a few large "winners"; 90% of

[19] It is not surprising that the leaders of the growing movement to union graduate assistants on private university campuses tend to be graduate students from the humanities and soft social sciences (Ehrenberg et. al forthcoming).

the universities in their sample received less than $2 million and almost half received less than $1 million.[20]

Licensing income received in one year depends upon the flow of investments in research that universities have made in the past. If we ignore this and the fact that the return on any particular research project may occur for a number of years in the future, a simple way of looking at the commercial returns that universities receive from their faculty members' research is to ask how the licensing income received by a university in one year relates to its own expenditures on research in that year. Licensing income received in fiscal year 2000 averaged 3.23% of total research expenditures in the year across the institutions in the AUTM sample. As we have noted, universities fund about 20% of their research expenditures out of their own resources, which suggests that licensing income averaged about 16% of institutions' research expenditures out of internal university funds in the year.

At first glance this seems like a significant return but this calculation is misleading for at least three reasons. First, the licensing income that universities receive is divided between the university and the researchers. So only a share of the revenue actually comes to the university itself. Second, focusing on the average ratio ignores the skewness in the distribution of research returns. The median institution in the sample licensing income was 0.83% of its total research revenue, which is about 4.2% of its internal volume of research expenditures. Third, given the volume of a university's research, licensing income and other forms of revenue from patents that are related to this research do not simply fall off trees. Rather, they must be "harvested". Considerable efforts must be

[20] See Blumenstyk (2002a). Some of these large winners were universities that cashed in equity positions that they had taken in companies, in lieu of receiving licensing income.

made by universities and their faculty members to decide if faculty members' discoveries have potential commercial value, to patent the discoveries, to then develop or seek partners to develop commercial potential, to negotiate licenses or equity positions, and to enforce patents.[21] All of these activities take resources. Indeed, the cost of trying to enforce patents alone can prove very expensive.[22]

While no comprehensive source of data on the costs that universities occur in trying to generate licensing income is currently available, summary information from the AUTM licensing survey permits us to make some back of the envelope calculations. During fiscal year 2000, the 142 U.S universities in the AUTM sample employed a total of 479.95 "licensing" full-time equivalent employees (FTEs) and 494.53 other FTEs in their technology transfer offices. They also incurred $117,927,842 in legal fees, of which third parties reimbursed only $53,685,716.[23] Hence these universities' net legal fees for technology transfer activities were roughly $64 million and they employed a total of about 975 employees. These employees include patent attorneys, other professionals and support staff. If we assume that the fully loaded costs of each employee (salaries, benefits, office space etc.) averaged $100,000 that year, the total expenses of technology transfer activities for these institutions were in the range of $161.5 million dollars, or an average of about $1.15 million per university.

Maintaining the assumption that the average fully loaded cost of each employee was $100,000, the AUTM survey responses allow us to compute an estimate of the net

---

[21] Thursby and Thursby (2000) describe this process in much more detail and provide estimates of licensing production functions.

[22] The University of Rochester has established an "eight figure" legal fund in its effort to obtain billions of dollars in royalties from the makers and marketers of the arthritis drug Celebrex (Blumenstyck 2002b). Recently, a federal district court judge ruled against the University and the case is now under appeal (Blumenstyck 2003).

[23] Association of University Technology Managers (2001), attachment D

licensing income (income after expenses) for 138 of the universities in the sample. The mean net licensing income in this sample was $6,554,200, but the median was only $343,952. By our calculations 51 of the 138 institutions actually lost income that year on their commercialization activities and we estimate that the median net licensing income for the 87 that made money was $1,309,828. When one remembers that the licensing income received by universities is split between them and the faculty members whose patents have generated the income, it seems clear that commercialization of research has yet to provide most universities with large amounts of net income to support the universities' scientific research activities.

References

Association of University Technology Managers, *AUTM Licensing Survey: FY 2000* (Northbrook IL: Association of University Technology Managers, 2001)

Goldie Blumenstyck, "Income from University Licenses on Patents Exceeded $1-Billion", *Chronicle of Higher Education* (March 22, 2002): A31 (2002a)

Goldie Blumenstyck, "Taking on Goliath: U. of Rochester Risks Millions in Patent Fight with Pharmaceutical Giants", *Chronicle of Higher Education* (September 20, 2002), A27 (2002b)

Goldie Blumenstyck, "Federal Court Dismisses U. of Rochester's Suit that Sought Billions for Patent Infringement", *Chronicle of Higher Education* (March 21, 2003), A21

Carnegie Foundation for the Advancement of Teaching, *A Classification of Institutions of Higher Education: 1994 Edition* (Princeton NJ: Carnegie Foundation for the Advancement of Teaching, 1994)

Carnegie Foundation for the Advancement of Teaching, *The Carnegie Classification of Institutions of Higher Education: 2000 Edition* (Princeton NJ: Carnegie Foundation for the Advancement of Teaching, 2001)

Ronald G. Ehrenberg, *Tuition Rising: Why College Costs So Much* (Cambridge MA: Harvard University Press, 2000)

Ronald G. Ehrenberg, "Studying Ourselves: The Academic Labor Market", *Journal of Labor Economics* 21 (April 2003): 267-289.

Ronald G. Ehrenberg and Julia Epifantseva, "Has the Growth of Science Crowded Out Other Things at Universities", *Change* 33 (July/August 2001): 46-52.

Ronald G. Ehrenberg, Daniel B. Klaff, Adam T. Kezsbom and Matthew P. Nagowski, "Collective Bargaining in American Higher Education" in Ronald G. Ehrenberg ed. *Governing Academia* (Ithaca NY: Cornell University Press, forthcoming)

Ronald G. Ehrenberg and Christopher L. Smith, "The Sources and Uses of Annual Giving at Selective Private Research Universities and Liberal Arts Colleges", *Economics of Education Review* (forthcoming)

Michael J. Rizzo and Ronald G. Ehrenberg, "Resident and Nonresident Tuition and Enrollment Decisions at Flagship State Universities", in Caroline Hoxby Ed., *College Decisions: How Students Actually Make Them and How They Could* (Chicago IL: University of Chicago Press, forthcoming)

Jerry G. Thursby and Marie C. Thursby, "Who is Selling the Ivory Tower? Sources of Growth in University Licensing", *National Bureau of Economic Research Working Paper No. W7718* (Cambridge MA: National Bureau of Economic Research, May 2000)

U.S. News & World Report, *2002 America's Best Colleges* (Washington DC, 2001)

Gordon Winston, "Subsidies, Hierarchies and Peers: The Awkward Economics of Higher Education", *Journal of Economic Perspectives* 13 (Winter 1999): 13-36.

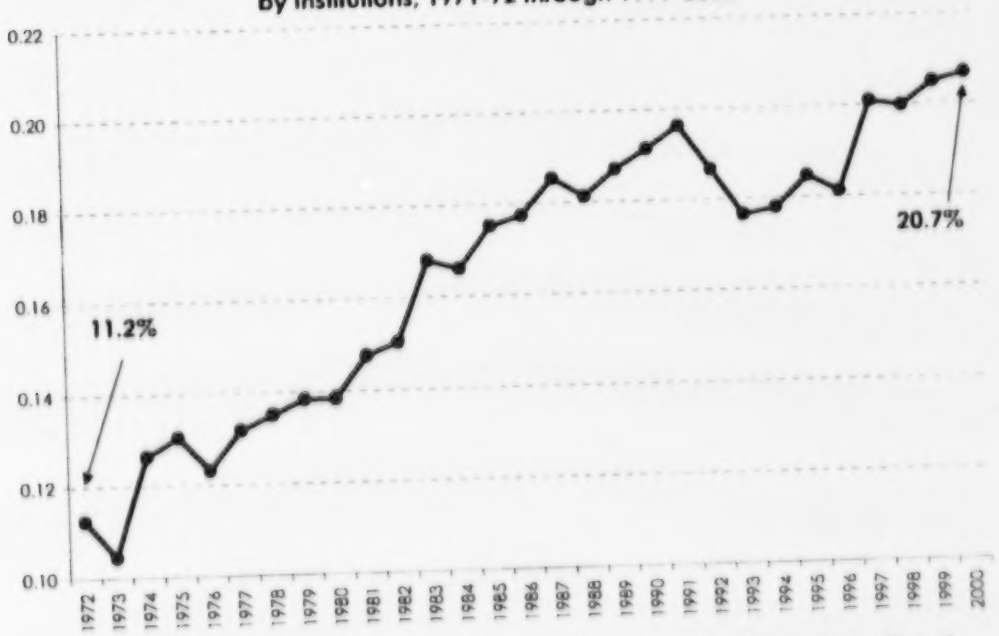
Table 1

SELECTED CORNELL NEWS SERVICE PRESS RELEASE HEADLINES THAT RELATE TO RESEARCH AT CORNELL DIRECTED AT IMPROVING HUMAN HEALTH: JANUARY- SEPTEMBER 2002

1. A simple, cost-effective screening test for those at-risk for abdominal aortic aneurysms (9/4)
2. Experimental therapy for deadly brain tumors can be more effective with longer treatment time (8/1)
3. Cooking sweet corn boosts its ability to fight cancer and heart disease by freeing healthful compounds (8/8)
4. "Good cholesterol" not only healthy for the heart, but also could be beneficial for the lungs (8/5/02)
5. Gene discovery in petunias could boost hybrid food yield (7/3)
6. Discovery of ripening gene could make store-bought tomatoes as tasty as homegrown (4/9)
7. E.Coli detection in food reduced from days to minutes (3/15)
8. Dog model for studying inherited human blindness (5/7)
9. Estrogen's role in preventing female cardiac disease (3/22)
10. How Vitamin C prevents cancer- but apples are better (1/22)
11. Cooking tomatoes boosts disease-fighting power (4/19)
12. Ergonomic changes help muscular skeletal problems (2/28)
13. Scientists demonstrate new strategy of using bone marrow stem cells to restore aging cardiac blood vessel-forming capacity (6/7)
14. Study illuminates cardiac scarring that leads to heart failure (5/24)
15. Harvesting stem cells for transplant in non-Hodgkin's lymphoma still possible after treatment with Bexxar (5/19)
16. Researchers report encouraging results with first combined antibody treatment for lymphoma (5/20)
17. HIV vaccines and low-daily does of Interleukin 2 may lead to permanent HIV immunity (3/1)
18. Researcher sees promise in use of stem cells and progenitor cells for brain repair (2/18)
19. First robot-assisted coronary bypass surgery in the U.S performed at New York-Presbyterian hospital (1/17)
20. Researcher describes the immune deficiency at the root of the commonest form of type 1 diabetes (1/2)

Source: Cornell University News Service 2002 Press Releases (available on the World Wide Web at http://www.news.cornell.edu)

Figure 1
Weighted Average Fraction of Total R&D Expenditures Contributed by Institutions, 1971-72 through 1999-2000



Source: R&D data from National Science Foundation Survey of Research and Development Expenditures at Universities and College. Faculty data from IPEDS via WebCASPAR.

BEST COPY AVAILABLE

TABLE 2

Average Mean Start-Up Costs for Deparments Reporting in the Category

		Private Research 1		*Private Non-Research I*		*Public Research 1*		*Public Non-Research 1*	
		Average	(Count)	Average	(Count)	Average	(Count)	Average	(Count)
AA	PHY	395,746	(9)	147,944	(18)	320,932	(42)	169,491	(56)
AA	BIO	403,071	(14)	199,754	(26)	308,210	(38)	172,582	(55)
AA	CHEM	489,000	(20)	221,052	(29)	441,155	(43)	210,279	(71)
AA	ENG	390,237	(19)	152,010	(20)	213,735	(52)	112,875	(46)
HA	PHY	563,444	(9)	254,071	(14)	481,176	(41)	248,777	(47)
HA	BIO	437,917	(12)	208,886	(22)	430,270	(37)	217,082	(49)
HA	CHEM	580,000	(17)	259,348	(23)	584,250	(40)	284,269	(60)
HA	ENG	416,875	(16)	209,057	(21)	259,494	(50)	146,831	(43)
AP	PHY	701,786	(7)	90,000	(2)	740,486	(29)	359,783	(23)
AP	BIO	957,143	(7)	481,458	(12)	651,087	(23)	438,227	(31)
AP	CHEM	983,929	(14)	532,046	(11)	989,688	(32)	550,349	(33)
AP	ENG	1,441,667	(9)	326,694	(14)	408,443	(38)	223,292	(23)
HP	PHY	1,000,000	(4)	418,333	(3)	1,110,577	(24)	455,882	(17)
HP	BIO	1,575,000	(5)	555,500	(10)	856,250	(16)	709,444	(27)
HP	CHEM	1,172,222	(9)	575,000	(8)	1,187,115	(26)	648,913	(23)
HP	ENG	1,807,143	(7)	452,000	(10)	472,086	(34)	254,597	(23)

*Tabulation of responses to the Cornell Higher Education Research Institute *Survey of Start-Up Costs and Laboratory Space Allocation Rules* that was mailed to 3 to 5 chairs of selected biological science, physical science and engineering departments at each research and doctoral university during the summer of 2002.

Where

AA average start-up costs for new assistant professors
HA high-end start-up costs for new assistant professors
AP average start-up costs for senior faculty
HP high end start-up costs for senior faculty

PHYS Physics and Astronomy
BIO Biology
CHEM Chemistry
ENG Engineering

BEST COPY AVAILABLE

Table 3
Panel Regression Results - OLS
FTE Undergraduate and Graduate Enrollment per Ranked Faculty
All RHS variables exogenous
(Standard Errors)

Explanatory Variables	***Privates (78 schools)***		***Publics (150 schools)***	
Internal Funding per faculty, in $10,000	0.106 (0.142)	**0.535** **(0.139)**	**0.212** **(0.031)**	**0.130** **(0.033)**
Total giving per student, in $1,000	-0.038 (0.041)	0.031 (0.039)	-0.025 (0.042)	-0.005 (0.041)
Endowment per student, in $1,000	-0.004 (0.003)	**0.007** **(0.003)**	**-0.031** **(0.009)**	**-0.039** **(0.009)**
State apps per student, in $1,000	0.280 (0.480)	-0.442 (0.460)	**-0.035** **(0.012)**	**-0.041** **(0.013)**
Share of enrollments - graduates	**6.5** **(2.7)**	**19.6** **(2.7)**	**-13.1** **(1.7)**	**-17.6** **(1.8)**
Fixed Institution Effects?	Yes	Yes	Yes	Yes
Fixed Year Effects?	No	Yes	No	Yes
Within R^2	0.047	0.161	0.069	0.105

Significant at 95% level in **BOLD**
All dollar values in $US 1998 dollars, data for AY77-98
Sources: NSF, HEGIS and IPEDS via WebCASPAR and Council on Aid to Education

Table 4
Panel Regression Results - OLS
Weighted Average Ranked Faculty Salaries
All RHS variables exogenous
(Standard Errors)

Explanatory Variables	***Privates (78 schools)***		***Publics (150 schools)***	
Internal Funding per faculty, in $10,000	**2.051** **(222)**	**392** **(107)**	**1.771** **(79)**	**540** **(47)**
Total giving per student, in $1,000	**410** **(64)**	**134** **(30)**	**-512** **(105)**	**-237** **(58)**
Endowment per student, in $1,000	**78** **(5)**	**31** **(2)**	**121** **(22)**	18 (12)
State apps per student, in $1,000	**-2,872** **(746)**	119 (351)	**269** **(31)**	**92** **(18)**
Share of enrollments - graduates	**57,033** **(4179)**	**4,484** **(2097)**	**53,998** **(4344)**	1,455 (2522)
Fixed Institution Effects?	Yes	Yes	Yes	Yes
Fixed Year Effects?	No	Yes	No	Yes
Within R^2	0.468	0.887	0.408	0.823

Significant at 95% level in **BOLD**
All dollar values in $US 1998 dollars, data for AY77-98
Sources: NSF, HEGIS and IPEDS via WebCASPAR and Council on Aid to Education

Table 5
Panel Regression Results - OLS
Instate Tuition Level
All RHS variables exogenous
(Standard Errors)

Explanatory Variables	***Privates (78 schools)***		***Publics (150 schools)***	
Internal Funding per faculty, in $10,000	**945** **(101)**	**165** **(45)**	**149** **(11)**	-11 (7)
Total giving per student, in $1,000	**178** **(29)**	**40** **(13)**	-22 (15)	**22** **(8)**
Endowment per student, in $1,000	**26** **(2)**	**4** **(1)**	**18** **(3)**	2 (2)
State apps per student, actual $	**-1,554** **(345)**	-132 (149)	**13** **(4)**	**-9** **(3)**
Share of enrollments - graduates	**29,237** **(1919)**	**4,822** **(883)**	**9,088** **(599)**	**1,507** **(368)**
Fixed Institution Effects?	Yes	Yes	Yes	Yes
Fixed Year Effects?	No	Yes	No	Yes
Within R^2	0.428	0.897	0.361	0.785

Significant at 95% level in **BOLD**
All dollar values in $US 1998 dollars, data for AY77-98
Sources: NSF, HEGIS and IPEDS via WebCASPAR and Council on Aid to Education

Table 6
2SLS Panel Data Estimate Summary
Coefficient on Internal Research Expenditures per Ranked Faculty - STUDENT-FACULTY Equation
Fixed Institution and Year Effects
(Standard Errors)

	Baseline (Table 3)		***Giving and External R&D Instrumented***		***Giving, External R&D and State Apps Instrumented***	
Specification	***Private***	***Public***	***Private***	***Public***	***Private***	***Public***
All Institutions	**0.535** **(0.139)**	**0.130** **(0.033)**	**0.620** **(0.139)**	0.033 (0.036)	**0.611** **(0.139)**	0.032 (0.036)
Research I Institutions	**0.262** **(0.072)**	**0.323** **(0.049)**	**0.251** **(0.071)**	**0.327** **(0.049)**	**0.250** **(0.071)**	**0.327** **(0.049)**
Non-Research I Institutions	0.780 (0.460)	**0.102** **(0.046)**	0.860 (0.468)	-0.092 (0.053)	0.857 (0.468)	-0.092 (0.053)

Significant at 95% level in ***BOLD***
All dollar values in $US 1998 dollars, data for AY77-98
Sources: NSF, HEGIS and IPEDS via WebCASPAR and Council on Aid to Education

Instruments include above exogenous variation plus: instruments created that represent the share of an institution's federal research expenditures that come from a given federal agency, times the change in that agency's budget. The agencies include the USDA, Department of Defense, NASA, NSF, Department of Health and Human Services and All Other Agencies. Other instruments include each institution's share of total research expenditures among its different academic disciplines, including Engineering, Life Sciences, Physical Sciences, Psychology, Social Sciences and Other Disciplines.

Table 7
2SLS Panel Data Estimate Summary
Coefficient on Internal Research Expenditures per Ranked Faculty - FACULTY SALARY Equation
Fixed Institution and Year Effects
(Standard Errors)

	Baseline (Table 4)		Giving and External R&D Instrumented		Giving, External R&D and State Apps Instrumented	
Specification	Private	Public	Private	Public	Private	Public
All Institutions	**392** **(107)**	**540** **(47)**	**399** **(105)**	**518** **(53)**	**350** **(107)**	**548** **(63)**
Research I Institutions	79 (105)	**237** **(77)**	45 (104)	**236** **(78)**	36 (109)	**350** **(110)**
Non-Research I Institutions	-280 (294)	**435** **(59)**	-248 (293)	**427** **(70)**	-227 (293)	**463** **(76)**

Significant at 95% level in ***BOLD***
All dollar values in $US 1998 dollars, data for AY77-98
Sources: NSF, HEGIS and IPEDS via WebCASPAR and Council on Aid to Education

Instruments include above exogenous variation plus: instruments created that represent the share of an institution's federal research expenditures that come from a given federal agency, times the change in that agency's budget. The agencies include the USDA, Department of Defense, NASA, NSF, Department of Health and Human Services and All Other Agencies. Other instruments include each institution's share of total research expenditures among its different academic disciplines, including Engineering, Life Sciences, Physical Sciences, Psychology, Social Sciences and Other Disciplines.

Table 8
2SLS Panel Data Estimate Summary
Coefficient on Internal Research Expenditures per Ranked Faculty - TUITION Equation
Fixed Institution and Year Effects
(Standard Errors)

	Baseline (Table 5)		***Giving and External R&D Instrumented***		***Giving, External R&D and State Apps Instrumented***	
Specification	***Private***	***Public***	***Private***	***Public***	***Private***	***Public***
All Institutions	**165**	-11	**154**	**-15**	**140**	-10
	(45)	(7)	**(45)**	**(8)**	**(46)**	(10)
Research I Institutions	-58	-11	-68	-13	-70	8
	(59)	(12)	(58)	(12)	(60)	(18)
Non-Research I Institutions	**234**	-9	**242**	-16	**237**	**-24**
	(108)	(9)	**(110)**	(10)	**(110)**	**(11)**

Significant at 95% level in ***BOLD***
All dollar values in $US 1998 dollars, data for AY77-98
Sources: NSF, HEGIS and IPEDS via WebCASPAR and Council on Aid to Education

Instruments include above exogenous variation plus: instruments created that represent the share of an institution's federal research expenditures that come from a given federal agency, times the change in that agency's budget. The agencies include the USDA, Department of Defense, NASA, NSF, Department of Health and Human Services and All Other Agencies. Other instruments include each institution's share of total research expenditures among its different academic disciplines, including Engineering, Life Sciences, Physical Sciences, Psychology, Social Sciences and Other Disciplines.

Table 9

Impact of Increase in Internal Research per Faculty by $10,000 in Privates and by $22,500 in the Publics on Outcomes

Results Including both Fixed Institutional and Year Effects

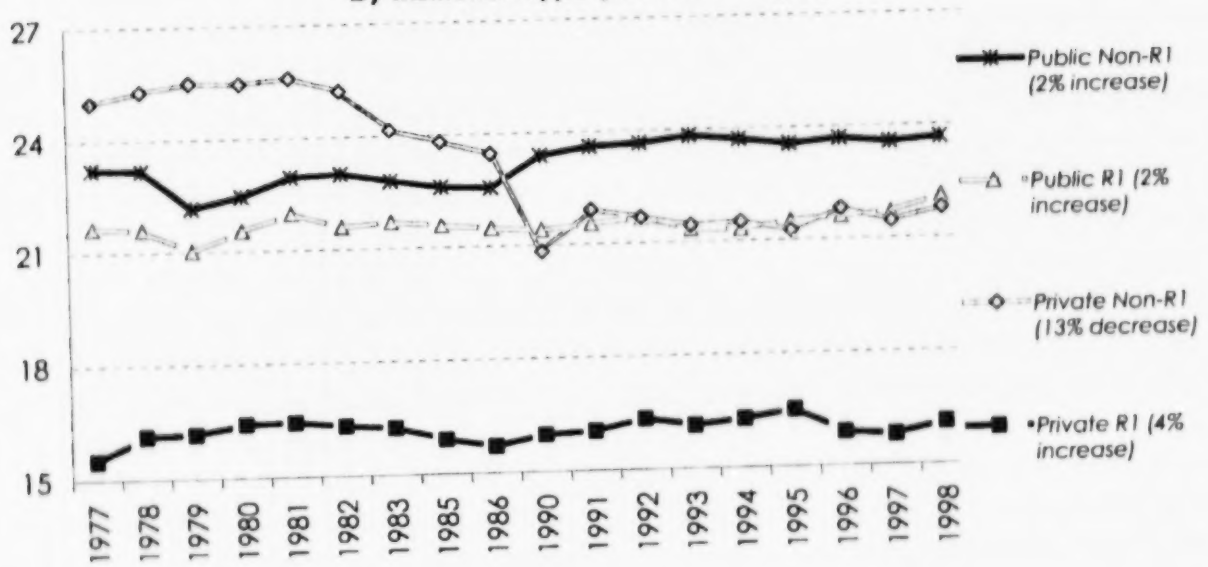
(Simulations on Research Funding Changes reflect actual changes from 1976-77 to 1997-98 in the data)

	Student-Faculty Ratio		Faculty Salaries		Tuition	
	Privates	*Publics*	*Privates*	*Publics*	*Privates*	*Publics*
Basic Model	**0.535**	**0.293**	**392**	**1216**	**165**	-25
Fully Endogenous Model						
Direct Effect	**0.611**	0.072	**350**	**1233**	**140**	-23
Indirect Effect	**-0.077**	0.219	**316**	**-1548**	**153**	-264
Total Effect	**0.534**	0.291	**666**	**-315**	**292**	-287
Mean Value of Dependent Variable in 1998	*19.68*	*23.06*	*67,381*	*58,640*	*17,941*	*3,407*

Significant at 95% level in **BOLD**

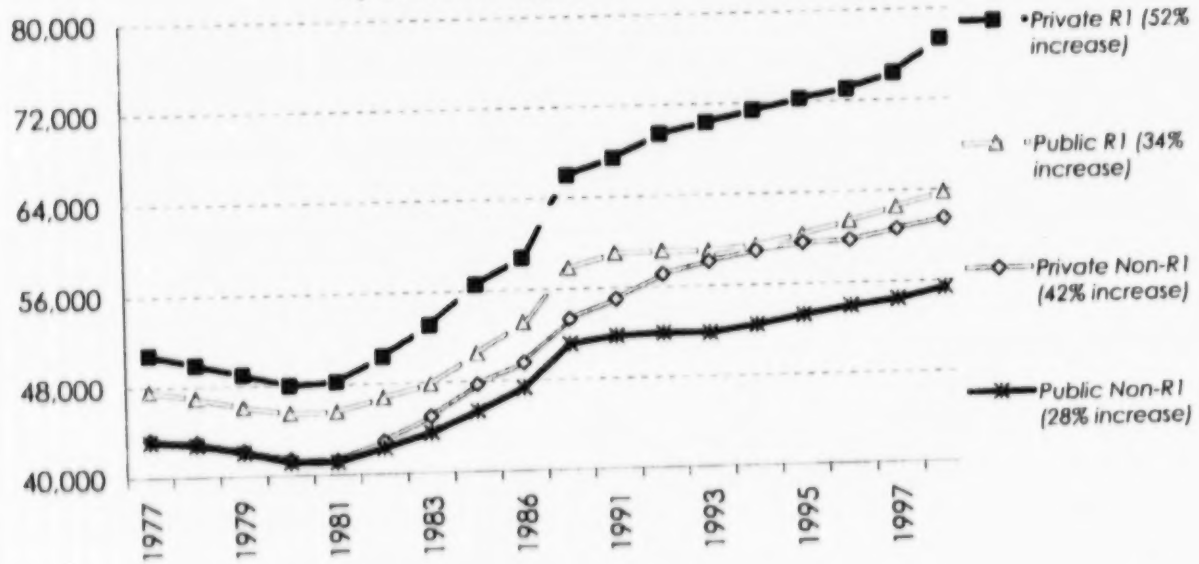
Appendix Figure 1

FTE Student per Ranked Faculty by Institution Type (1977AY-1998AY)



Appendix Figure 2

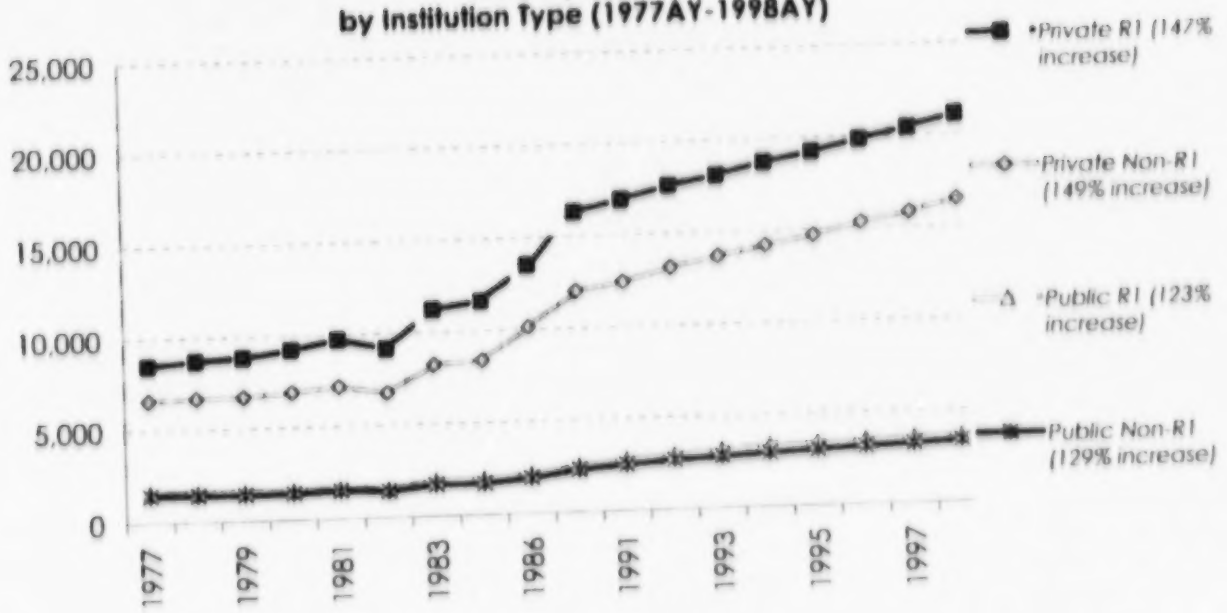
Weighted Average Ranked Faculty Salaries (Real $98) by Institution Type (1977AY-1998AY)



BEST COPY AVAILABLE

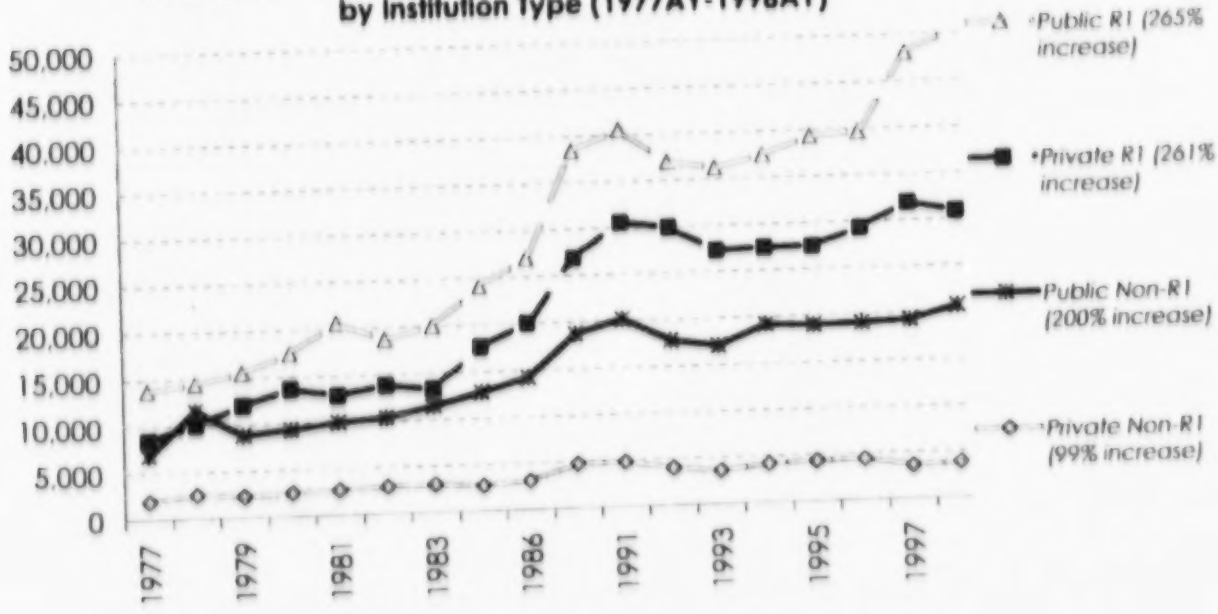
Appendix Figure 3

Tuition (Real $98)
by Institution Type (1977AY-1998AY)



Appendix Figure 4

Institutional Research Expenditures per Ranked Faculty (Real $98)
by Institution Type (1977AY-1998AY)



BEST COPY AVAILABLE

Appendix Table 1
Two Stage Least Squares Panel Data Regression Results
Endogenous Vars: All Research Vars, State Apps and Giving
(Standard Errors)

	GIVING per Student		***STATE APPROPRIATIONS per Student***		***External R&D per Faculty***	
Explanatory Variables	***Priv.***	***Pub.***	***Priv.***	***Pub.***	***Priv.***	***Pub.***
Total Research per faculty, in $10,000	**394** **(25)**	**249** **(10)**				
External Research per faculty, in $10,000			-1.8 (3.5)	-45 (39)		
Internal Research per faculty, actual $					**1.73** **(0.15)**	**0.77** **(0.06)**
Fixed Institution Effects?	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Year Effects?	Yes	Yes	Yes	Yes	Yes	Yes

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

NOTICE

Reproduction Basis

[X] This document is covered by a signed "Reproduction Release (Blanket)" form (on file within the ERIC system), encompassing all or classes of documents from its source organization and, therefore, does not require a "Specific Document" Release form.

[ ] This document is Federally-funded, or carries its own permission to reproduce, or is otherwise in the public domain and, therefore, may be reproduced by ERIC without a signed Reproduction Release form (either "Specific Document" or "Blanket").